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Entitled: **IN-MOLD COATING IN MULTIPLE INJECTION MOLDING PART CAVITIES**

Enclosed are:

17 Pages of **SPECIFICATION**

00 Page of **ABSTRACT**

04 Sheets of **DRAWING** (FIGURES 1-4)

_____ **CLAIMING SMALL ENTITY STATUS**

___ Independent Inventor

___ Small Business

___ Non-profit Organization

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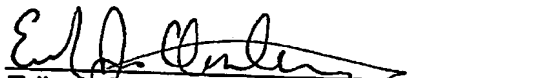

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IN-MOLD COATING IN MULTIPLE INJECTION MOLDING PART CAVITIES

Background of the Invention

Field of the Invention

[0001] The present invention relates to in-mold coating multiple injection molding part cavities and controlling the flow of an in-mold coating composition that is injected into multiple injection molding part cavities. More particularly, the present invention relates to a method of (1) injection molding multiple thermoplastic articles in multiple injection molding part cavities and in-mold coating the multiple articles with an in-mold coating composition, (2) using only a single injector to in-mold coat the multiple thermoplastic articles and/or (3) controlling the flow of the injected in-mold coating composition on the multiple injection molded articles such that the multiple articles are only coated on desired surfaces or portions of surfaces. The present invention finds particular application as an apparatus and method for injection molding two thermoplastic articles within two part cavities defined by mold halves of a single injection molding machine, in-mold coating the two articles with an in-mold coating composition using a single in-mold coating composition injector and controlling the flow of the injected in-mold coating composition on the two articles. The present invention will be described with particular reference to this application. However, it is to be appreciated that the invention may relate to other similar environments and applications.

Description of the Prior Art

[0002] Molded thermoplastic and thermoset articles, such as those made from polyolefins, polycarbonates, polyesters, polyethylenes, polypropylenes, polystyrenes and polyurethanes, are utilized in numerous applications including those for the automotive, marine, recreation, construction, office products, and outdoor equipment industries. Oftentimes, it is desirable to apply a surface coating to a molded thermoplastic or thermoset article. For example, the molded articles may be used as one part in multi-part assemblies. To "match" the finish of the other parts in such

assemblies, the molded articles may require application of a surface coating that has the same finish properties as the other parts. Coatings may also be used to improve surface properties of the molded article such as uniformity of appearance, gloss, scratch resistance, chemical resistance, weatherability, and the like. In addition, surface coatings may be used to facilitate adhesion between the molded article and a separate finish coat to be later applied to the molded article.

[0003] Numerous techniques have been developed to apply surface coatings to molded plastic articles. Many of these techniques involve the application of a surface coating to plastic articles after they are removed from their molds. These techniques are often multi-step processes involving surface preparation followed by spray-coating the prepared surface with paint or other finishes. In contrast, in-mold coating provides a means of applying a surface coating to molded plastics prior to ejection from the mold. In-mold coating can eliminate the separate manufacturing process of applying a coating to the article upon ejection from the mold thereby reducing the overall cost of manufacturing the article.

[0004] Historically, much of the work with in-mold coatings has been done on molded articles made from thermosets. Thermosets, e.g., phenolics epoxies, cross-linked polyesters, and the like, are a class of plastic composite materials that are chemically reactive in their fluid state and are set or cured by a reaction that causes cross-linking of the polymer chains. Once cured, subsequent heating may soften, but will not restore thermosets to a fluid state.

[0005] More recently, there has been an interest in in-mold coating articles made from thermoplastics. Thermoplastics are a class of plastic materials that can be melted, cooled to a solid form, and repeatedly re-melted and solidified. The physical and chemical properties of many of the thermoplastic materials, together with their ease of moldability, make them materials of choice in numerous applications in the automotive, marine, recreation, construction, office products, outdoor equipment and other fields.

[0006] Because of the inherent differences between the materials, the mold designs and molding techniques used with thermosets are different than those used with thermoplastics. Molds for use with thermosets are typically designed as

mated halves with shear edges. One half is typically stationary and the other half typically telescopes vertically over the stationary half. To create a molded article, an uncured thermoset is usually placed on the stationary half with the telescoping half moved apart from the stationary half. After the uncured thermoset is introduced to the mold, heat is applied to both of the mold halves and pressure is applied to the telescoping half of the mold thereby closing the mold halves and forcing and holding the uncured thermoset against the mold surface. Thus, the thermoset article is forced into shape by the movable mold half bearing down on the thermoset material. Subsequently, the formed thermoset article is allowed to cure and can then be removed or ejected from the mold.

[0007] Unlike the design of the molds typically used with thermosets, the molds used with thermoplastics usually are of a "clam shell"-like design having mated halves that meet at a parting line. One of the mated halves typically remains stationary whereas the other half of the mold is typically movable between a closed position and an open, retracted position. To form a molded article, the movable half is moved to its closed position and held closed under a clamping force thereby forming a contained molding cavity. Molten thermoplastic material is injected into the molding cavity. The molded article is formed by thoroughly filling the cavity with the thermoplastic composition and allowing the composition to sufficiently cool and solidify. During the entire molding process, the movable mold half is maintained in its closed position. After molding, the mold halves can be opened and a finished, molded article can be ejected therefrom.

[0008] Various methods have been used to apply in-mold coatings to molded thermoset and thermoplastic articles. For example, the coatings can be sprayed onto the surface of an open mold prior to closing. However, spray coating can be time-consuming and, when the coating is applied using a volatile organic carrier, may require the use of containment systems. Other in-mold coating processes involve lining the mold with a preformed film of coating prior to molding. The drawback of this in-mold coating process is that, on a commercial scale, this technique can be cumbersome and costly.

[0009] Processes have also been developed wherein a fluid coating is injected onto and dispersed over the surface of a molded thermoset part and cured. A common method of injecting a fluid in-mold coating onto the surface of a molded thermoset involves curing the article in the mold to the point that it has hardened sufficiently to accept the coating, reducing the pressure against the telescoping mold half to crack open or part the mold, injecting the fluid coating, and re-pressurizing the mold to distribute the coating over the surface of the molded article. The cracking or parting of the mold involves releasing the pressure exerted on the telescoping mold half to sufficiently move it away from the molded article creating a gap between the surface of the part and the telescoping mold half. The gap allows the coating to be injected onto the surface of the part without removing the part from the mold.

[0010] Owing to differences in mold design and molding conditions, processes wherein the mold is cracked or parted prior to injection of an in-mold coating are generally not used for the in-mold coating of injection molded thermoplastics. When molding thermoplastics, it is generally necessary to maintain pressure on the movable mold half to keep the cavity closed and prevent resin from escaping along the parting line. Further, it is often necessary to "pack" or maintain pressure on the thermoplastic material during molding which also necessitates keeping the cavity closed. Packing the mold helps to provide a more uniform crystalline or molecular structure in the molded article. Without packing, the physical properties of the molded thermoplastic article tend to be impaired.

[0011] In addition to the problem of resin escaping along the parting line, packing constraints can sometimes create other problems when an in-mold coating is to be injected into a mold containing a thermoplastic article. Specifically, some commercially available in-mold coatings are thermoset materials that cure by the application of heat. Were such coatings to be injected after a molded thermoplastic article has been sufficiently packed to allow the mold to be depressurized and parted or cracked, the molded thermoplastic may lack sufficient heat to cure the coating. Thus, for these types of coatings to cure on a thermoplastic article, they are desirably injected prior to depressurizing the mold.

[0012] Because injection molding of thermoplastics does not generally permit the mold to be parted or cracked prior to injection of the in-mold coating into the mold cavity, the in-mold coating must be injected under sufficient pressure to compress the thermoplastic article in all areas that are to be coated. By compressing the thermoplastic article, the in-mold coating is able to interpose between molding surfaces of the mold cavity and outer surfaces of the molded thermoplastic article. The method and apparatus used to physically inject the liquid in-mold coating into the molding cavity of an injection molding machine at a pressure sufficient to compress the outer surfaces of the molded thermoplastic article is described in commonly owned, copending U.S. Patent Application Serial No. 60/422,784 entitled "Dispense and Control Apparatus And Method For In-Mold Coating An Injection Molded Thermoplastic Article" filed on October 31, 2002, expressly incorporated herein by reference.

[0013] As the in-mold coating is injected into the mold cavity and onto the thermoplastic article, the flow of the in-mold coating can be controlled such that only desired surfaces or portions of surfaces of the thermoplastic article are coated and that those surfaces are optimally coated. Further, the flow of the in-mold coating can be controlled so as to limit the in-mold coating from escaping through the parting line or entering the area near the thermoplastic injection orifice.

[0014] A method for selectively controlling in-mold coating flow is described in commonly owned, copending U.S. Patent Application Serial No. 10/045,481 entitled "Selectively Controlling In-Mold Coating Flow" filed on October 22, 2001, expressly incorporated herein by reference. The '481 application teaches how to selectively control the flow and thickness of an in-mold coating composition as it is injected into a mold cavity and onto a molded thermoplastic article. Generally, the '481 application teaches that by controlling the thickness or depth of various areas or sections of the molded thermoplastic article, desired areas of the article can be preferentially coated. Specifically, the '481 application teaches that when a molded article is provided with an area of increased relative thickness at or near the location of the in-mold coating injection, in-mold coating flow is promoted. When the molded article is provided with a runner section or preferred flow channel, in-mold coating flow over the surface of the molded article is promoted. Additionally, when the molded article is

provided with a containment flange, the flange acts as a barrier and prevents the in-mold coating from leaking or seeping off a desired surface and/or out of the mold cavity.

[0015] Another method for selectively controlling in-mold coating flow is described in commonly owned, copending U.S. Patent Application Serial No. 10/152,132 entitled "In-Mold Coating Injection Inlet Flow Control" filed on May 20, 2002, expressly incorporated herein by reference. The '132 application teaches the use of "flow zones" near the in-mold coating injection inlet area to promote the flow of in-mold coating from the injection inlet area.

[0016] Still another method for selectively controlling in-mold coating flow is described in commonly owned, copending U.S. Patent Application Serial No. 10/136,877 entitled "Removable Defined Flange for In-Mold Coating Containment" filed on May 1, 2002. The '877 application discloses a containment flange functioning like the containment flange described in the '132 application but with the added feature of being configured to be removable from the coated thermoplastic article. The removable flange is able to be easily removed such as by hand with little effort.

[0017] Still yet another method for selectively controlling in-mold coating flow is described in commonly owned, copending U.S. Patent Application Serial No. 10/150,128 entitled "In-Mold Coating Barrier for a Substrate Injection Orifice" filed on May 16, 2002, expressly incorporated herein by reference. The '128 application discloses the use of a mold structure formed as part of the thermoplastic article that provides a barrier preventing in-mold coating flow into the thermoplastic injector orifice, gate pin assembly or the like.

[0018] In some applications, multiple thermoplastic articles may be simultaneously injection molded on a single injection molding machine. More particularly, a single injection molding machine can include a set of mold halves that define more than one part cavity. When the mold halves define multiple part cavities, multiple articles can be molded therein, typically one article per part cavity. In these types of applications, it may be desirable to in-mold coat the multiple molded thermoplastic articles for the reasons discussed above. Accordingly, there is a need for an injection molding and in-mold coating arrangement that allows thermoplastic articles molded in multiple part cavities of a set of mold halves to be in-mold coated. It may be

further desirable to in-mold coat the multiple molded thermoplastic articles using a single in-mold coating injector. Accordingly, there is also a need for an injection molding and in-mold coating arrangement that allows thermoplastic articles molded in multiple part cavities of a set of mold halves to be in-mold coated by a single in-mold coating injector. Whether in-mold coating with a single in-mold coating injector or with multiple in-mold coating injectors, there will also be a need for controlling the flow of the injected in-mold coating composition on the multiple injection molded articles such that the articles are only coated on desired surfaces or portions of surfaces.

Brief Summary of the Invention

[0019] The present invention provides an injection molding and in-mold coating arrangement that overcomes the foregoing difficulties and others and provides the aforementioned and other advantageous features. In accordance with one aspect of the present invention, an injection molding and in-mold coating arrangement is provided for injection molding multiple thermoplastic articles in multiple part cavities of a set of mold halves and in-mold coating the multiple articles. More particularly, in accordance with this aspect of the invention, the arrangement includes an injection molding apparatus that is capable of injection molding multiple thermoplastic articles within a single set of mold halves by providing multiple molding part cavities defined by the mold halves. The arrangement further includes an in-mold coating apparatus that is capable of in-mold coating the multiple injection molded thermoplastic articles.

[0020] In accordance with another aspect of the present invention, an injection molding and in-mold coating arrangement is provided for injection molding multiple thermoplastic articles in multiple part cavities of a set of mold halves and in-mold coating the multiple articles. More particularly, in accordance with this aspect of the invention, the arrangement includes an injection molding apparatus that is capable of injection molding multiple thermoplastic articles within a single set of mold halves by providing multiple molding part cavities defined by the mold halves. The arrangement further includes an in-mold coating apparatus that is capable of in-mold coating the multiple injection molded thermoplastic articles using a single in-mold coating injector.

[0021] One advantage of the present invention is that it allows multiple thermoplastic articles to be molded and coated within a single set of mold halves on an injection molding apparatus.

[0022] Another advantage of the present invention is that it allows multiple thermoplastic articles to be molded and coated within a single set of mold halves on a single injection molding apparatus wherein only a single in-mold coating injector is used to coat the multiple articles.

[0023] Still another advantage of the present invention is the provision of an injection molding and in-mold coating arrangement that is able to produce a higher quantity of molded and coated thermoplastic articles during each injection molding and coating cycle than heretofore realized.

[0024] Still other advantages and benefits of the present invention will become apparent to those skilled in the art and upon reading and understanding the following detailed description.

Brief Description of the Drawings

[0025] The invention may take physical form in various components and arrangements of components, and in various steps and arrangements of steps. The drawings are only for purposes of illustrating preferred embodiments and are not to be construed as limiting the invention.

[0026] Figure 1 is a side view of a molding apparatus having a movable mold half and a stationary mold half that together define a plurality of molding part cavities.

[0027] Figure 2 is a schematic plan view of the movable mold half in a closed position and the stationary mold half showing (in hidden lines) the plurality of part cavities, a runner section, a sprue section and a second injector passageway.

[0028] Figure 3 is a schematic cross-sectional view taken along the line 3-3 of Figure 2 showing the runner section fluidly connected to the part cavities.

[0029] Figure 4 is a perspective view of an in-mold coating dispense and control apparatus connectable to the second injector of Figure 1.

Detailed Description of the Invention

[0030] With reference to Figure 1, a conventional injection molding machine 10 is shown including a first mold half 12 and a second mold half 14. The first mold half 12 preferably remains in a stationary or fixed position relative to the second movable mold half 14. In Figure 1, the movable mold half 14 is shown in an open position. The movable mold half 14 is movable to a closed position wherein the first and second mold halves 12,14 mate with one another to form a plurality of contained part cavities 16 therebetween. More specifically, the mold halves 12,14 mate along surfaces 18 and 20 when the movable mold half 14 is in its closed position forming a parting line 22 (Figure 2) therebetween and around the plurality of part cavities 16.

[0031] The movable mold half 14 reciprocates generally along a horizontal axis relative to the first or fixed mold half 12 by action of a clamping mechanism 24 with a clamp actuator 26 such as through a hydraulic, pneumatic or mechanical actuator as known in the art. The clamping pressure exerted by the clamping mechanism 24 should have an operating pressure in excess of the pressures generated or exerted by either one of a first composition injector 30 and a second composition injector 32. In the preferred embodiment, the pressure exerted by the clamping mechanism 24 ranges generally from about 2,000 pounds per square inch (psi) or 138 bar to about 15,000 psi or 1033 bar, preferably from about 4,000 psi or 276 bar to about 12,000 psi or 827 bar, and more preferably from about 6,000 psi or 413 bar to about 10,000 psi or 689 bar of the mold surface.

[0032] With additional reference to Figure 2, the mold halves 12,14 are shown in a closed position abutting or mating with one another along the parting line 22 to form the plurality of part cavities including a first part cavity 34 and a second part cavity 36. It should be readily understood by those skilled in the art that the design of each of the part cavities 34,36 can vary greatly in size and shape according to the desired end product or article to be molded in each of the part cavities 34,36. Additionally, the number of part cavities defined by the mold halves 12,14 can vary. In the illustrated embodiment, the first mold half 12 includes a sprue passageway 38 and a runner section 40 for fluidly communicating between an inlet 42 on a locating ring 44 located at the rear of the mold half 12 and the part cavities 34,36. The locating ring 44

includes a female radius surface for mating with the first composition injector 30 as will be described in more detail below.

[0033] The first composition injector 30 is that of a typical injection molding apparatus which is well known to those of ordinary skill in the art. The first composition injector 30 is generally capable of injecting a thermoplastic composition, generally a resin or polymer, into the part cavities 34,36 by forcing the thermoplastic composition through the sprue passageway 38 and the runner section 40. The first injector 30 used to inject the thermoplastic composition is positioned to inject material from the fixed half 12 of the mold and the second composition injector 32 is positioned to inject an in-mold coating composition from the movable mold half 14.

[0034] In Figure 1, the first composition injector 30 is shown in a "backed off" position, but it is readily understood that the same can be moved in a horizontal direction so that a nozzle or resin outlet 46 of the first injector 30 having a male radius surface can mate with the female radius surface of the mold half 12. In the mated position, the injector 30 is capable of injecting its contents into the mold cavities 34,36 through the sprue passageway 38 and the runner section 40. For purposes of illustration only, the first composition injector 30 is shown as a reciprocating-screw machine wherein a first composition can be placed in a hopper 48 and a rotating screw 50 can then move the composition through a heated extruder barrel 52, where the first composition or material is heated above its melting point. As the heated material collects near the end of the barrel 52, the screw 50 acts as an injection ram and forces the material through the nozzle 46 and into the first mold half 12. The nozzle 46 optionally has a valve (not shown) at the open end thereof and the screw 50 generally has a non-return valve (not shown) to prevent the backflow of material thereinto.

[0035] The first composition injector 30 is not meant to be limited to the embodiment shown in Figure 1 but can be any apparatus capable of injecting a thermoplastic composition into the mold cavities 34,36. For example, the injection molding machine can have a mold half movable in a vertical direction or can be a "stack-mold" with center injection. Other suitable injection molding machines include many of those available from Cincinnati-Milacron, Inc. of Cincinnati, Ohio; Battenfeld Injection Molding Technology of Meinlerzhagen, Germany; Engel Machinery Inc. of

York, Pennsylvania; Husky Injection Molding Systems Ltd. of Bolton, Canada; BOY Machines Inc. of Exton, Pennsylvania and others.

[0036] With reference to Figures 2 and 3, the runner section 40 includes an upper T-shaped portion 54 and a lower T-shaped portion 56 for delivering the thermoplastic composition injected through the sprue 38 into the part cavities 34,36. The runner section 40 is defined across the parting line 22 by both of the mold halves 12,14. Where the runner section 40 intersects the part cavities 34,36, inlet orifices 58 are formed. Adjacent to each inlet orifice 58, the runner section 40 includes a tapered portion 60 that allows for relatively easy removal of the thermoplastic composition formed in the runner section 40 from the articles or parts formed in the part cavities 34,36.

[0037] A second injector passageway 62 extends through the second mold half 14 to the runner section 40. The second injector passageway 62 allows a nozzle 64 of the second injector 32 to extend into the mold half 14 and fluidly communicate with the runner section 40. The nozzle 64 includes a pin or valve 66 that is movable between an open position wherein fluid communication is permitted between the second injector 32 and the runner section 40 and a closed position wherein fluid communication is prevented between the second injector 32 and the runner section 40. The valve 66 is normally bias or urged toward the closed position (as shown), but is selectively movable toward the open position by the second injector 32.

[0038] In the preferred embodiment, the second injector passageway 62 intersects with the runner section 40 at location 68 (illustrated in phantom lines in Figure 3). Preferably, the portion of the runner section 40 adjacent the location 68 is shaped to form a flat runner section of the thermoplastic composition. Forming a flat runner section is intended to promote better flow distribution of the in-mold coating composition that is injected from the second injector 32 onto the runner formed in the runner section 40. Further, it is preferable that the cross-section of the passageway 62 be smaller than the cross-section of the portion of the runner section 40 adjacent the location 68. This sizing relationship and the flatness of the runner section 40 will better urge or direct the injected in-mold coating along the formed runner toward the part cavities 34,36 and away from the parting line 22.

[0039] With reference to Figure 4, an in-mold coating dispense and control apparatus 70 is capable of being connected to the molding apparatus 10 and, specifically, the second injector 32 for providing in-mold coating capabilities and controls. The control apparatus 70 is described in the above-referenced commonly-owned, co-pending U.S. Patent Application Serial No. 60/422,784 entitled "Dispense and Control Apparatus and Method for In-Mold Coating an Injection Molded Thermoplastic Article" filed on October 31, 2002.

[0040] Briefly, the control apparatus 70 includes a receiving cylinder 72 for holding an in-mold coating container filled with an in-mold coating composition. A suitable in-mold coating composition is disclosed in commonly owned, U.S. Patent No. 5,777,053 entitled "In-Mold Coating Compositions Suitable As Is For An End Use Application" issued July 7, 1998, expressly incorporated herein by reference. The control apparatus 70 further includes a metering cylinder or tube 74 and an air-driven transfer pump 76. The metering cylinder 74 is selectively and fluidly connectable to the coating container in the receiving cylinder 72. More specifically, a fluid line (not shown) connects the coating container to the metering cylinder 74. A valve (not shown) is provided on the fluid line for controlling communication therethrough. The transfer pump 76 is adapted to selectively pump the in-mold coating composition of the coating container to the metering cylinder 74 when the fluid line valve is in an open position.

[0041] Using conventional fluid communication lines (not shown), the metering cylinder 74 is fluidly connectable to the second injector 32 of the molding apparatus 10. A hydraulic means such as a hydraulically driven piston (not shown) is provided for selectively evacuating in-mold coating composition held in the metering cylinder 74 therefrom as will be described in more detail below. The evacuated in-mold coating composition is directed by and through the fluid communication lines to the second injector 32. The control apparatus 70 includes appropriate connections (not shown) for connecting the control apparatus 70 to a conventional electric power source and a conventional compressed air source. Specifically, the control apparatus 70 includes an electric box 78 that is capable of being connected to a conventional 460 volt AC or DC power outlet. The electric box 78 includes a plurality of controls 80 and a touch pad controller 82 thereon for controlling the dispensing of the in-mold coating

composition from the apparatus 70 to the second injector 32 and for controlling the second injector valve 66. The electric power source provides power for the electronics, electronic controls and the hydraulic pump of the apparatus 70. The compressed air source provides power for the air-driven transfer pump 76.

[0042] To make an in-mold coated thermoplastic article according to a preferred method of the present invention, with reference to Figure 1, a thermoplastic first composition is placed in the hopper 48 of the molding apparatus 10. Suitable thermoplastic materials include, but are not limited to, polyethylene, terephthalate (PET), nylon, acrylonitrile butadiene styrene (ABS), polystyrene, polycarbonate, acrylic, acetal, polyolefins such as polyethylene and polyethylene, polypropylene, and polyvinyl chloride (PVC). The foregoing list is not meant to be exhaustive but only illustrative of the various thermoplastic materials useful in the practice of the invention.

[0043] Prior to injecting the first composition to form the molded articles, the mold halves 12,14 are closed by the clamp mechanism 24 to create the contained molding part cavities 34,36. In the closed position, the clamping mechanism 24 maintains a clamping pressure sufficient to maintain the mold halves 12,14 in closed relation even when the first composition and the second composition are injected into the part cavities 34,36 under pressure. Also prior to injecting the first composition, the first injector 30 is moved into nesting or mating relation with the first mold half 12.

[0044] Through conventional means, i.e., using the heated extruder barrel 52 and the rotating screw 50, the first injector 30 heats the first composition above its melting point and directs the heated first composition toward the nozzle 46 of the first injector 30. If the nozzle 46 is equipped with a nozzle valve, it is moved to an open position for a predetermined amount of time to allow a corresponding quantity of the first composition to pass through the sprue passageway and the runner section to fill the part cavities 34,36. The screw 50 provides an injection pressure or force that urges the first composition into the part cavities 34,36 until the nozzle valve is returned to its closed position. More specifically, the part cavities 34,36 are filled and packed by the first composition. Once the part cavities 34,36 are filled and packed, the molded first composition is allowed to cool thereby forming molded articles in the part cavities 34,36.

A portion of the first composition will remain in the sprue passageway 38 and the runner section 40 forming therein, respectively, a sprue and a runner.

[0045] After specified surfaces of the molded articles in the part cavities 34,36 have cooled below their melt points or otherwise reached a temperature or modulus sufficient to accept or support an in-mold coating, the in-mold coating composition can be injected into the part cavities 34,36 and onto the molded articles. If the in-mold coating composition is cured by heat then it would be desirably injected before the surfaces of the molded articles have cooled too much such that curing would be inhibited. To inject the coating, the valve 66 is moved to the open position and the hydraulic means is actuated to evacuate a predetermined amount of the in-mold coating composition from the metering cylinder 74, through the second injector 32, and into the part cavities 34,36. More specifically, from the second injector 32, the in-mold coating composition is directed through the nozzle 64 and onto the flat portion of the runner adjacent the location 68. As described in more detail below, the in-mold coating composition is directed along the runner section 40 and into the part cavities 34,36 to coat desired surfaces of the molded articles. The flat portion promotes the flow of the in-mold coating composition into the cavities 34,36.

[0046] It is important to note that the mold is not opened or unclamped before the in-mold coating is applied. That is, the mold halves 12,14 maintain the parting line 22 and generally remain substantially fixed relative to each other while both the first and second compositions are injected into the mold cavities 34,36. The in-mold coating composition spreads out and coats a predetermined portion or area of the molded articles as will be described in more detail below. Immediately or very shortly after the in-mold coating composition is fully injected into the mold cavities 34,36, the apparatus 70 allows the valve 66 of the second injector 32 to return to its closed position thereby preventing further injection of the in-mold coating composition into the mold cavities 34,36.

[0047] After the predetermined amount of the in-mold coating composition is injected into the mold cavities 34,36 and it covers or coats the predetermined areas of the articles, the coated articles can be removed from the mold 12,14. However, before the mold halves are parted, the in-mold coating composition is cured by components

present within the coating composition. The cure is optionally heat activated, from sources including the articles themselves or the mold halves 12,14 which are at or above the curing temperature of the in-mold coating composition. Cure temperature will vary depending on the in-mold coating composition utilized. As mentioned above, it is important to inject the in-mold coating composition, if its curing is heat activated, before the molded articles have cooled to the point below where proper curing of the coating can be achieved. These types of in-mold coating compositions require a minimum temperature to activate the catalyst present therein which causes a cross-linking reaction to occur, thereby curing and bonding the coatings to their molded articles.

[0048] Controlling the flow of the in-mold coating composition as it passes from the injector 32 to the cavities 34,36 and onto the articles can be done by controlling the thickness of one or more portions of the articles as well as by controlling the thickness and profile design of the runner section 40 leading to the part cavities 34,36. For example, the runner section 40 can be shaped to form a containment flange on the runner to limit and thereby control the flow of the in-mold coating composition. The containment flange functions like those discussed in '132 and '822 applications, discussed and incorporated by reference above. Specifically, the containment flange contains the in-mold coating composition as it flows between the walls defining the runner section 40 and the runner formed therein. Once the controlled flow of the in-mold coating composition reaches the cavities 34,36, the shape of the molded cavities therein can be such that it further controls the flow of the in-mold coating composition in the cavities 34,36 and on the molded articles such that only desired surfaces or portions of surfaces are coated. In the illustrated embodiment, the containment flange on the runner could be formed along the parting line 22 and the surfaces to be coated on each of the articles formed in the part cavities 34,36 could be adjacent the second mold half 14. Thus, the in-mold coating composition could be contained and only allowed to flow on the second mold half side of the parting line 22.

[0049] Although the present invention is illustrated and described as having two mold halves defining a pair of cavities that receive an in-mold coating composition from a single injector, other arrangements are contemplated. For example, the mold halves may define one or more than two part cavities. Another arrangement

would employ separate in-mold coating injectors and/or control and dispense apparatus for each cavity defined in the mold halves. Yet another arrangement would employ a single injector adapted to provide in-mold coating to part cavities located in different sets of mold halves. These arrangements and others are to be considered within the scope of the present invention.

[0050] Further alternative arrangements are contemplated. In one alternate embodiment, the in-mold coating injector 32 is mounted on the first mold half 12 and in-mold coats a side of the runner formed in the runner section 40 adjacent the first mold half. Alternatively, with the second injector 32 mounted on the first mold half 12, the in-mold coating composition could be directed through the mold half 12 to the sprue formed in the sprue passageway 38. Various arrangements of containment flanges could be formed along the sprue passageway 38 and the runner section 40 to direct the in-mold coating composition injected into the sprue to the part cavities 34,36. In another alternate embodiment, the second injector 32 could be oriented to directly inject the in-mold coating compositions onto a desired surface of one of the articles formed in the part cavities 34,36. The in-mold coating composition could then be directed to coat that article and flow along the runner formed in the runner section 40 to in-mold coat the article formed in the other of the part cavities 34,36. In still yet another alternative embodiment, the second injector 32 could be used to deliver the in-mold coating composition directly to a plurality of locations on any combination of the article formed in the first cavity 34, the article formed in the second cavity 36, the sprue and/or the runner. The second injector 32 would deliver the in-mold coating composition to the plurality of locations by using passages that branch off one another.

[0051] The invention has been described with reference to the preferred embodiments. Obviously, modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations.

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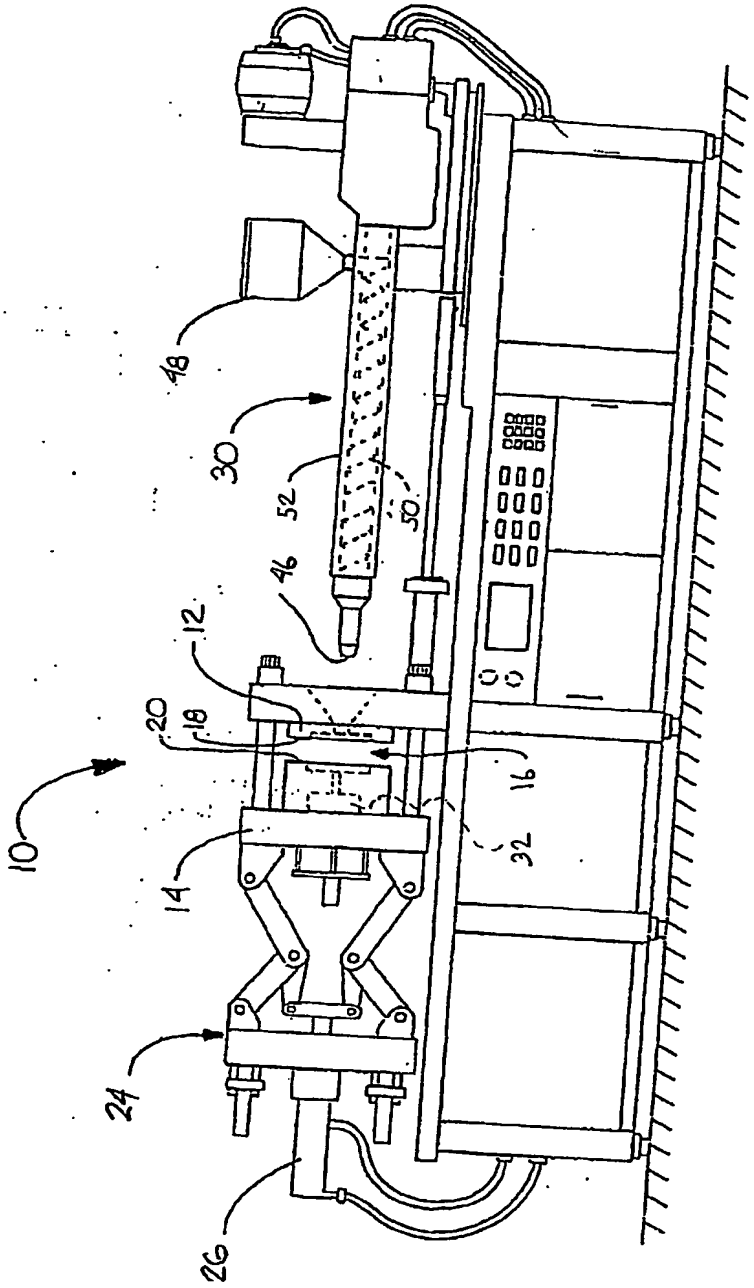

FIGURE 1

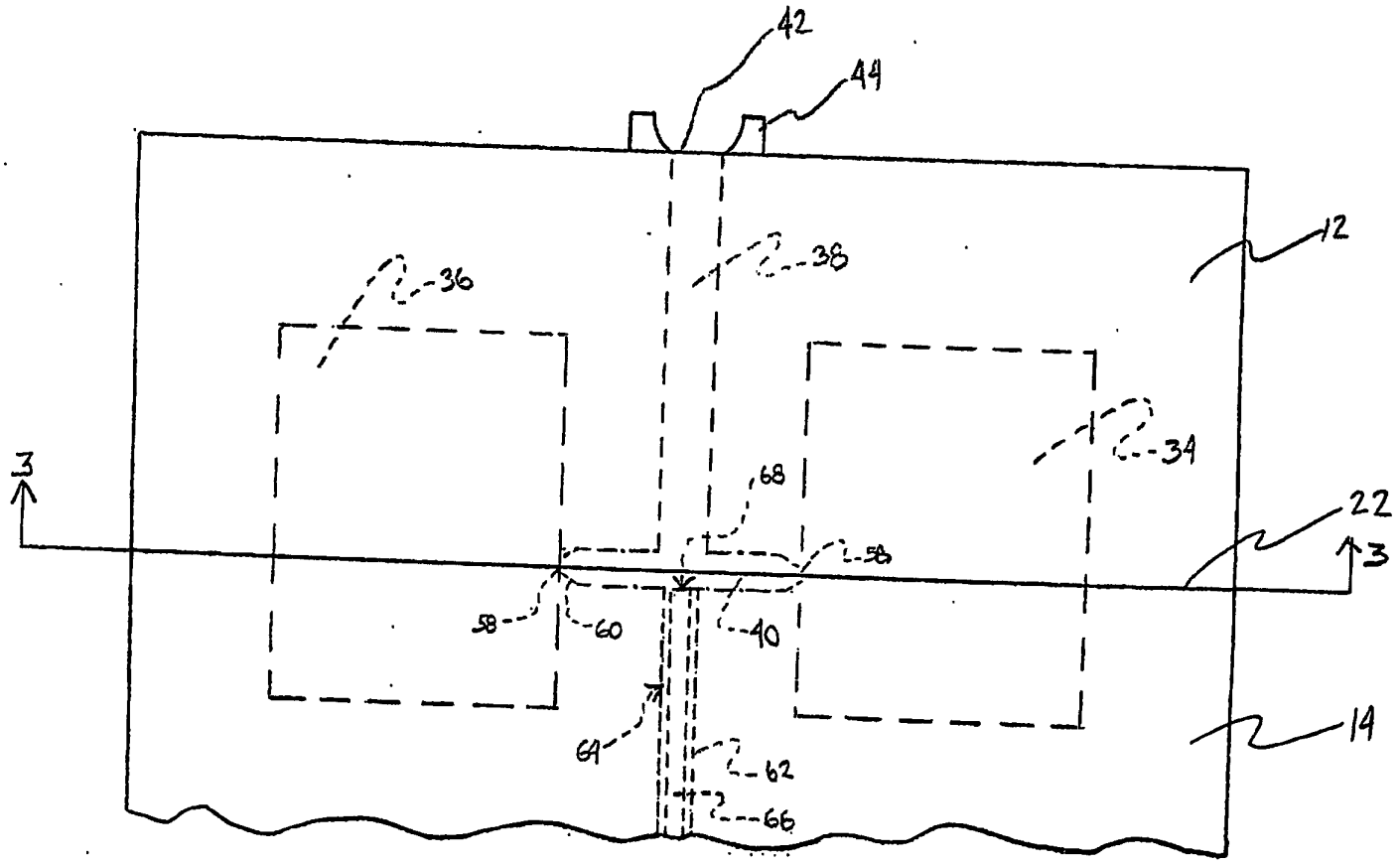

FIGURE 2

FIGURE 3

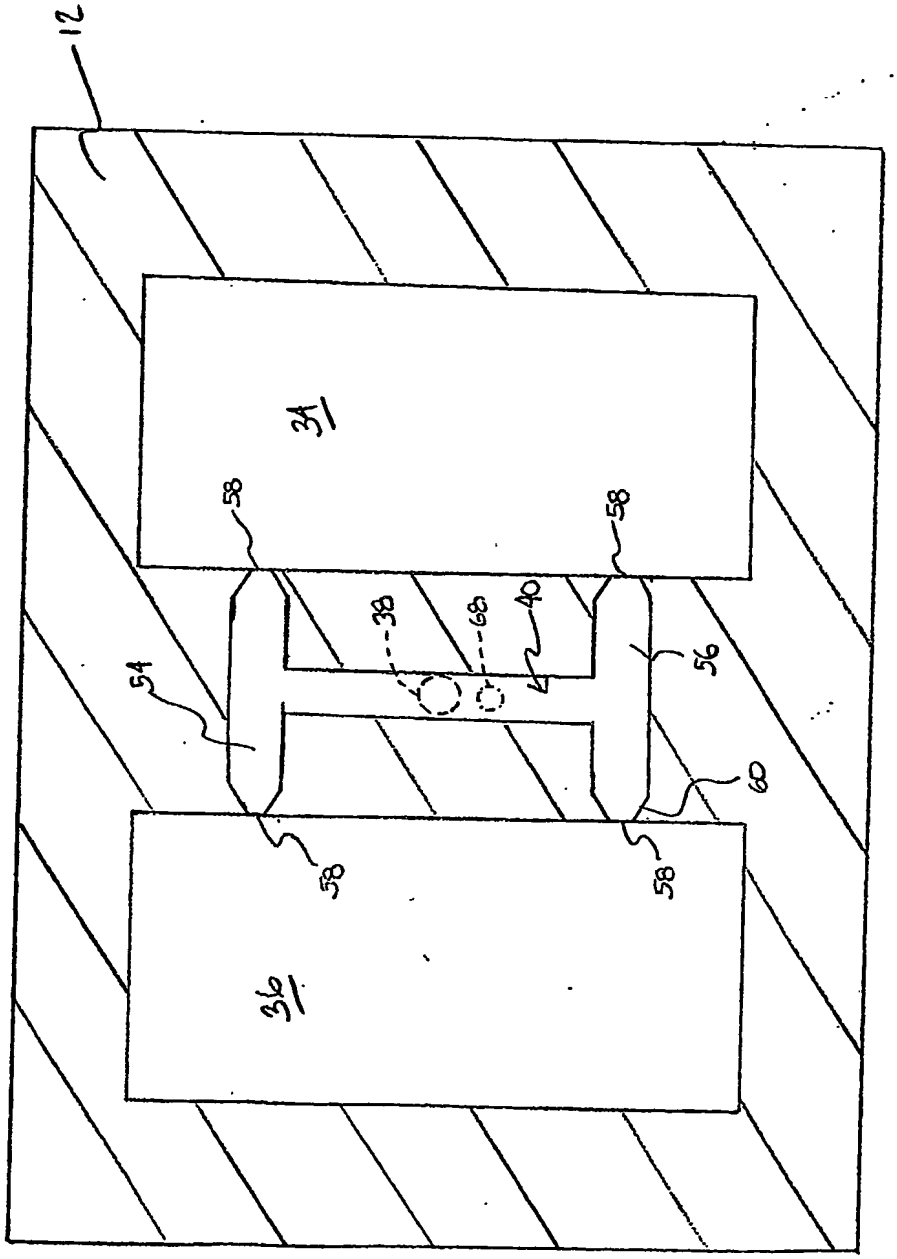

FIGURE 4